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(54) Vehicule route finding system.

(57) A vehicle route finding system whereby a vehicle borne receiver (10) picks up signals from a radio navigation system (14, 15, 16, 23), such as the Loran-C system, and transmits data related to its location to a central station, via the data channel on a radiotelephone link. At the central station a computer (16) determines the vehicle's position from the Loran data and, knowing its desired destination, retransmits routing information back to the driver. True position values additionally transmitted from the vehicle are used to compensate for propagation errors.

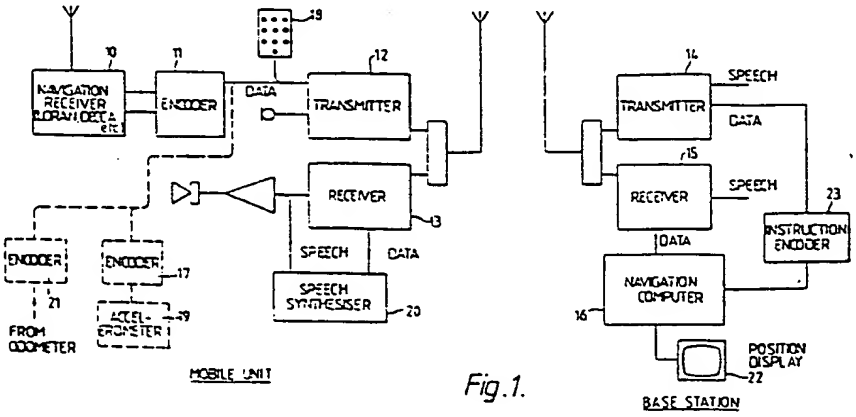

Fig.1.

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VEHICLE ROUTE FINDING SYSTEM

This invention relates to a vehicle route finding system. More particularly it relates to a system whereby the geographical location of a road vehicle can be accurately determined and a route to a desired destination indicated to the driver of that vehicle.

Radio navigational (position finding) systems such as Loran-C have now been developed to the stage where they can be used to determine the geographical location of a mobile station such as a vessel, aircraft or land-based vehicle to within a few tens of metres. Loran-C is a pulsed low frequency (100 KHz) hyperbolic radio navigation system in which a master transmitting station and two or more secondary stations all of known location transmit a pulsed signal. By measuring the time delay between the reception of a signal from two pairs of stations, a vehicle borne receiver can locate its position. Fuller details of the operation of the Loran system can be found in Loran-C User Handbook published by US Coastguard, Department of Transportation (May 1980).

The use of radio position finding systems such as Loran-C, or Decca, for land-based vehicles has been proposed in the past (e.g. US patents 3711856, 3766552, and 4106022). However, partly for reasons of cost, and partly for reasons of insufficient accuracy, radio position finding systems, while employed for many years for aircraft and ship navigation, have so far found little practical use for land vehicle navigation.

As regards accuracy, it is the inherent inaccuracy of the radio navigation systems which has thus far militated against their widespread practical application for locating and guiding land vehicles, as the demands on accuracy are much greater for guiding a vehicle within the

strict confines of a roadnetwork. The problem of insufficient accuracy for land-based navigation is compounded by obstacles, such as raised terrain, and buildings and other structures, in the path of the radio waves. Such obstacles may cause propagation errors which, in their turn, lead to inaccurate or ambiguous determination of the position of a vehicle.

The aforementioned US patents 3711856 (D.J. Adrian) and 4106022 (J.D. Last), are concerned with reducing the cost of radio navigation systems. According to the disclosure in these patents low cost radio navigation systems can be provided by transferring the process of calculating the position of a mobile station from the mobile station to a central computer. This transfer of processing is accomplished by retransmitting the position information received at the mobile station in a suitable manner to the computer, thus enabling the equipment carried on the mobile station itself to be comparatively simple. The two patents propose different ways of performing the re-transmission with the least possible degradation of the position information. US patent 4106022 also refers in passing to the possibility of employing a fixed reference receiver station in addition to the mobile stations and the fixed navigation transmitters, and using the difference between the apparent position and the actual position of the fixed reference station to compensate for propagation errors.

The present invention is based on the appreciation by the applicants that the mobile stations provide a suitable and flexible means for increasing the accuracy of position finding and route guidance by radio navigation.

According to the present invention, in a vehicle route finding system comprising a vehicle borne receiver capable of receiving signals from a radio navigation system and

for deriving information relating to the location of the vehicle from the signals, communication means carried by said vehicle whereby said location related information may be communicated to a computer together with information related to a desired destination of the vehicle and whereby resultant routing information may be communicated back to the vehicle driver, there are provided means to communicate separately to said computer the true position of the vehicle, and the computer is arranged to use differences between the derived and the true location to correct for errors due to propagation irregularities in that area.

The means to communicate the true position may conveniently comprise means for providing a clearance signal to the computer on arrival at the destination, and/or means to input and transmit the true position at the beginning of a journey when the starting position is known.

In addition, or as an alternative to means for communicating the true position at the beginning and/or the end of a journey, there may be provided vehicle borne means to provide additional information about the true position of the vehicle. These may comprise, for example, means to measure the distance travelled from the starting or another suitably chosen reference point, or for example an accelerometer which indicates vehicle accleration, in particular centripetal accelerations as the vehicle travels round corners.

The position information received at the vehicle is preferably transmitted to the computer via a conventional mobile radio communications system, such as, for example, a cellular radio system.

By using the mobile stations of the system to provide the position information required to enable the computer

to correct for propagation errors, it becomes possible to progressively refine the position finding provided by the system since even a relatively small number of mobile stations will in due course accumulate a large number of visited destinations. By thus obtaining frequent up-dating of the position information held in the computer, it is also possible to provide an adaptive system of vehicle position finding and route guiding, since there will usually be a sufficiently large number of transmissions to ensure dynamic readjustment of the position information when, for example, a new building being erected causes a systematic change in the propagation pattern.

A preferred embodiment of the present invention will now be described with reference to the accompanying drawings, of which:-

Figure 1 is a schematic block diagram of a mobile station and a base station of a vehicle route finding system, and

Figure 2 serves to illustrate a method of calculating corrections in position.

In the system according to the invention, a navigation receiver 10 such as a Loran receiver, is carried by the vehicle. The pulse time difference data from the receiver 10 passes to an encoder 11 and a radiotelephone transmitter 12 from where it is transmitted to a base station 14. A computer 16 at the base station calculates the vehicle's position taking into account any known propagation irregularities. These will conveniently have been obtained in the manner detailed below, and may, for example be stored in the computer as a table of corrections.

The vehicle driver initially indicates his desired destination or a series of destinations to the computer 16

at the base station 14 by way of a keyboard 18 connected to his radiotelephone 12. The position may be in the form of X-Y coordinates in relation to a street map, or alternatively he may key in the street name and building number for conversion to X-Y coordinates in the central computer. The computer 16 being now in possession of the vehicle's location and desired destination, computes an optimum route to that destination and relevant instructions are transmitted to the driver over the radiotelephone link in the form of appropriately coded data. These instructions are received by a radiotelephone receiver 13 and are either displayed to the driver in a head-up display (not shown) or given aurally by a synthesized voice unit 20 operating through the audio stages of the radiotelephone.

The communication channel between the vehicle and the base station is maintained either continuously or intermittently such that as the vehicle moves along the route, its changing position as determined by the data from the receiver 10, allows the computer 16 to update the route instructions information to he driver. Any deviations by the driver from the optimum route can be taken into account by the computer which will compute a new optimum route and issue appropriate instructions.

An additional feature may be provided in the form of a 'help' button which when pressed by a driver who has lost his way or is not confident that he is able to continue the journey by following the latest set of instructions, generates a special signal followed by the received Loran-C readings. On receipt of this special 'help' signal, the computer will give immediate directions such as to enable the driver to find his way again.

On reaching his destination, the driver sends an "arrival" signal to the central unit. The computer

calculates and stores the charges to be incurred and then either clears the route calculations or, in the case of multiple destinations, awaits a restart signal from the mobile.

The "arrival", or clearance, signal which is sent by the driver on arrival at his destination, provides the computer with an indication of the true position of the vehicle since the physical location of the destination is known to the computer 16. Thus, if transmitted to the computer 16, together with the received Loran-C readings for that location, it enables the computer, from any discrepancies between the computed location derived from the Loran-C readings and the actual location, to correct for propagation irregularities in subsequent position determinations for vehicles in that area. A further check may be carried out if the driver were to key in his known starting position, and these be transmitted together with the received Loran-C readings for that position, at the start of his journey.

The errors in the position as determined from the time- or phase-differences of the navigation system are caused mainly by variations in the terrain over which pass the radiowaves from the navigation transmitters. One method of calculating the correction for such errors is as follows.

The first step is to transform the position as determined by the time- or phase-differences in the radio navigation system to X-Y coordinates. Techniques for achieving this transformation are well known and are used in several radio navigation systems. The calculation gives the apparent position in relation to the map grid, e.g. the Ordnance Survey grid reference, in the form of two 4-digit numbers to provide an accuracy of ten metres. For example the apparent position of point P in the graph of Figure 2 would be (2430, 3120).

Figure 2 shows the point P together with points (x_1, y_1), (x_2, y_2) etc. for which corrections to the apparent positions have been already determined on previous occasions as shown in the table of Figure 2.

The known points closest to P are next calculated from

$$d_r = [(x_r - x_p)^2 + (y_r - y_p)^2]^{1/2}$$

In the example shown, it is evident that the point with coordinates (x_5, y_5) is closest.

The second closest point to P on the opposite side of it is then found. This requires the conditions

$$\text{sign } (x_r - x_p) \neq \text{sign } (x_5 - x_p)$$

and

$$\text{sign } (y_r - y_p) \neq \text{sign } (y_5 - y_p)$$

In the example shown, the point with coordinates (x_3, y_3) will not fulfil these latter conditions although it is the second closest point to P. The point with coordinates (x_6, y_6) is therefore chosen.

The X and Y corrections to be applied to the coordinates of point P are then calculated by interpolation to be +8 and +5 respectively so that the true position of P is (2438, 3125).

Since the corrected position coordinates are available at the central computer, it is a simple matter to display the vehicle position on a visual display unit 22 superimposed on a street map. This facility is particularly useful for operators of fleets of vehicles (delivery vans, hire cars, etc) as it enables them to know the position of all vehicles at all times.

Algorithms for finding the shortest route subject to known constraints between two points on a plane are well established. For vehicle route-finding, the main constraint is that the route must follow roads suitable for vehicles, with directional restrictions (one-way streets) where necessary. Account can also be taken of temporary restrictions such as road works, accidents, etc.

If it is assumed that minimum journey time rather than minimum distance is important to most users, the central computer can work out routes to avoid known areas of traffic congestion at certain times. By accumulating experience for a large number of monitored journeys, an intelligent knowledge based system can be built up to provide the quickest route between any two points in the area covered. The system may therefore be used even by drivers who are familiar with the route to provide the shortest journey time.

If a substantial number of users are making journeys at the same time, the computer can take account of the additional "congestion" it could cause by routing vehicles along particular streets. Some of the vehicles could then be directed along alternative routes. Thus if the use of the system becomes widespread, it would provide an effective means of overall traffic control in urban areas.

Although the system hereinbefore described will for many purposes provide adequate position indication and route direction in most areas, further information may be fed back from the vehicle to the central computer 16, over the radio link to give increased accuracy. This is particularly advantageous if noise and/or interference reduces the effectiveness of the radio navigation signal.

Examples of such additional sources of information are:

a. the vehicle odometer reading; this gives a check on distance travelled;

b. accelerometer 19; this indicates the vehicle accelerations, particularly the centripetal accelerations as the vehilcle goes round corners, etc.

The information is suitably encoded in encoders 21 and 17 respectively and fed to the transmitter 12.

Although the preferred embodiment of the invention makes use of the existing Loran-C radio navigation system, any other system of comparable accuracy and which would allow for a vehicle borne receiver of convenient size, could be used.

CLAIMS

1. A vehicle route finding system comprising a vehicle borne receiver (10) capable of receiving signals from a radio navigation system (14, 15, 16, 23) and deriving information relating to the location of the vehicle from the signals, communication means (12, 13) carried by said vehicle whereby said location related information may be communicated to a computer (16) together with information related to a desired destination of the vehicle and whereby resultant routing information may be communicated back to the vehicle driver, characterized in that means (12, 18, 17and 19, 21) are provided to transmit separately the true position of the vehicle to said computer, the computer being arranged to use differences between the derived and the true location to correct for errors due to propagation irregularities in that area.
2. A system as claimed in Claim 1 wherein said communication means includes a mobile radio communications transmitter/receiver (12, 13) carried by said vehicle and wherein said computer is situated at a fixed central location.
3. A system as claimed in Claims 1 and 2 wherein the communications means comprise cellular radio communications means.
4. A system as claimed in any of Claims 1 to 3 wherein said routing information is communicated to the vehicle driver by way of a speech synthesizer device.
5. A system as claimed in any preceding claim wherein the true position is transmitted on arrival at the destination and/or at the beginning of a journey.

6. A system as claimed in any preceding claims wherein the vehicle borne equipment further comprises vehicle motion monitoring devices (19) whose output is communicated to the computer 16.

7. A system as claimed in claim 6 wherein the motion monitoring device is an accelerometer.

8. A system as claimed in claim 6 wherein the motion monitoring device is an odometer.

9. A method of operating a radio vehicle route finding system comprising a computer, a plurality of navigational radio transmitters transmitting navigation signals, and a plurality of mobile stations, wherein the mobile stations receive position information from the navigational transmitters, transmit the position information to the computer for evaluation, and receive the evaluated position information including route instructions, characterized in that true positions communicated by the mobile stations is used to correct for propagation errors of the navigation signals.

10. A method as claimed in claim 9 wherein the true position communicated is the position of the mobile vehicle at arrival at a destination and/or at the beginning of a journey.

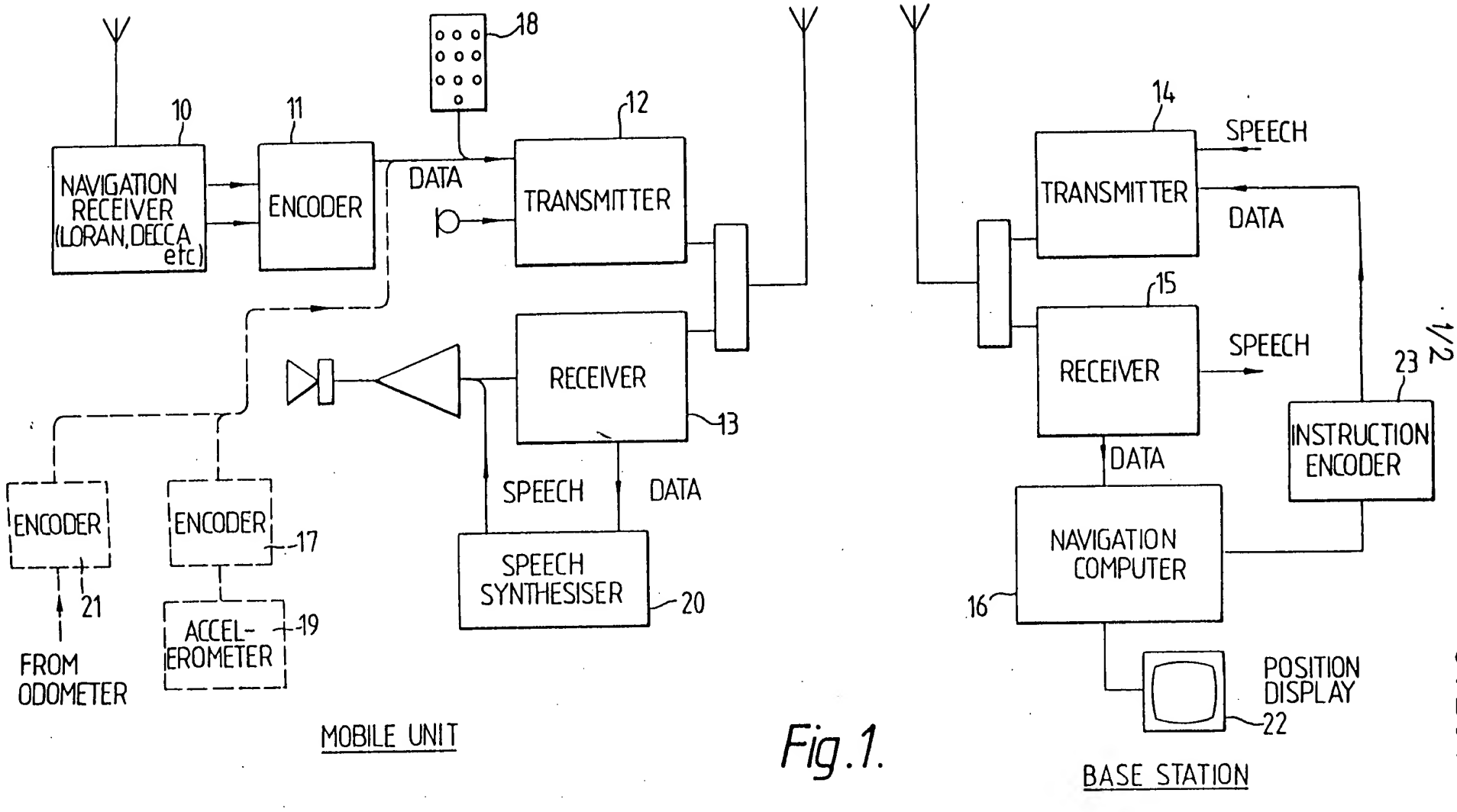

Fig.1.

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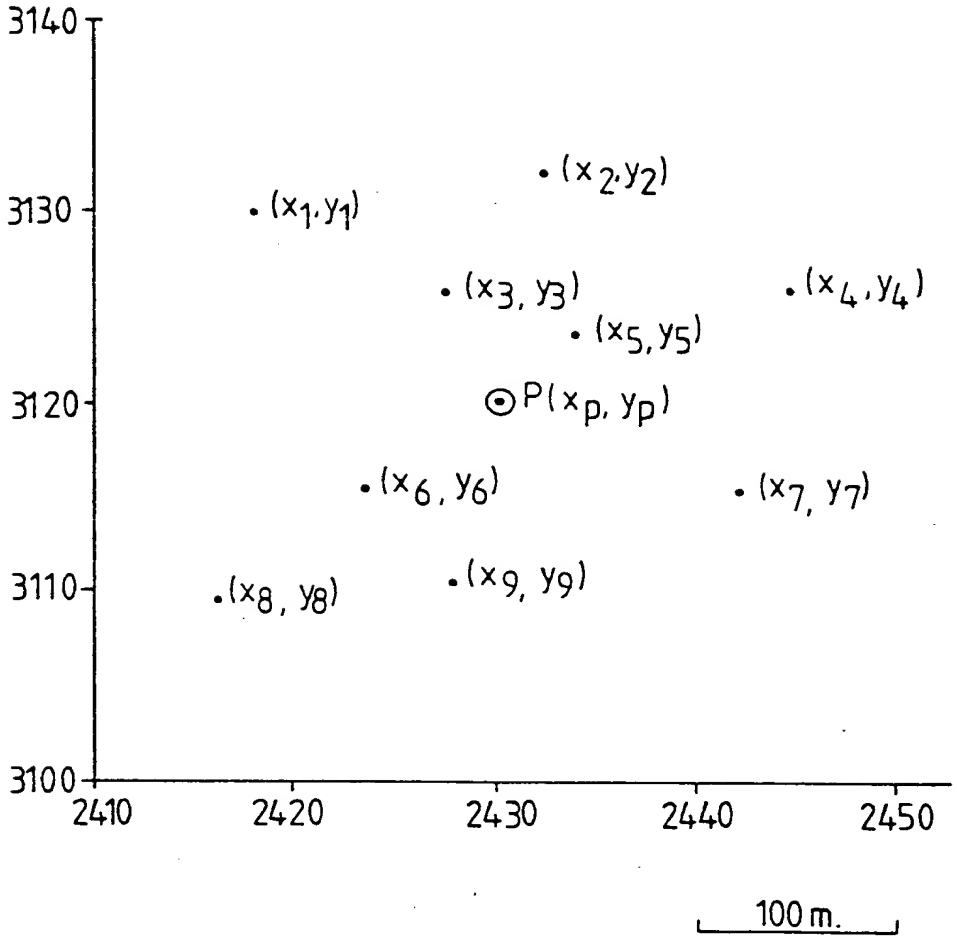

POINT	X POS^{N}	XCCT^{N}	Y POS^{N}	YCCT^{N}
x_1 y_1	2418	+4	3130	0
x_2 y_2	2432	+8	3132	−3
x_3 y_3	2428	+12	3126	−4
x_y y_4	2444	+10	3126	−7
x_5 y_5	2434	+10	3124	−1
x_6 y_6	2424	+5	3116	+11
x_7 y_7	2442	+2	3115	+12
x_8 y_8	2416	−1	3110	+2
x_9 y_9	2428	−1	3111	−3

Fig. 2.

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EUROPEAN SEARCH REPORT

0123562
Application number

EP 84 30 2814

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
Y	PROCEEDINGS OF THE NATIONAL ELECTRONICS CONFERENCE, vol. 34, 1980, pages 359-362, Oakbrook, Illinois, USA; D.J. BERRY et al.: "Electronic correction systems for LORAN-C signals reception (ECSLSR)" * Page 359, paragraph I *	1,2,5, 9,10	G 01 S 5/02
Y	FR-A-2 414 733 (W. WEISSER) * Page 6, line 32 - page 10, line 34; page 12, claim 3; figures 1,2 *	1,2,5, 9,10	
A	WESCON TECHNICAL PAPERS, vol. 20, part 20, paper 33/3, pages 1-7 of part 33/3, North Hollywood, USA; J. VAN DEWERKER: "Loran vehicle location systems" * Pages 6,7 *	1,2,6-8	TECHNICAL FIELDS SEARCHED (Int. Cl. ³) G 01 S
A	IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, vol. VT-26, no. 2, May 1977, pages 187-191, New York, USA; D.J. SYMES: "Multiuser area-coverage automatic vehicle monitoring program" * Whole document *	1,2,6, 8	

-/-

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	01-08-1984	VAN WEEL E.J.G.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EUROPEAN SEARCH REPORT

0123562
Application number

EP 84 30 2814

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
A	US-A-3 750 166 (J.S. DEARTH) * Column 7, line 61 - column 8, line 4 *	4	
A	PATENTS ABSTRACTS OF JAPAN, vol. 6, no. 156(P-135)(1034), 17th August 1982; & JP - A - 57 73616 (FURUNO DENKI K.K.) 08-05-1982 * Whole document *	1,9	
D,A	US-A-3 766 552 (M.S. HAJDUK) * Column 1, line 43 - column 2, line 28; column 3, line 10 - column 15, line 4; figures 1-14 *	1,9	
D,A	US-A-4 106 022 (J.D. LAST) * Column 8, lines 20-30; figure 5 *	1,9	

TECHNICAL FIELDS SEARCHED (Int. Cl. ³)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	01-08-1984	VAN WEEL E.J.G.

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